



# 1 pF Off Capacitance, 1 pC Charge Injection, $\pm 15$ V/12 V *i*CMOS™ Quad SPST Switches

Preliminary Technical Data

## ADG1211/ADG1212/ADG1213

### FEATURES

- 2 pF off capacitance
- 1 pC charge injection
- 33 V supply range
- 150  $\Omega$  on resistance
- Fully specified at +12 V,  $\pm 15$  V
- No  $V_L$  supply required
- 3 V logic-compatible inputs
- Rail-to-rail operation
- 16-lead TSSOP and 16-lead LFCSP packages
- Typical power consumption:  $<0.03 \mu\text{W}$

### APPLICATIONS

- Automatic test equipment
- Data acquisition systems
- Battery-powered systems
- Sample-and-hold systems
- Audio signal routing
- Video signal routing
- Communication systems

### GENERAL DESCRIPTION

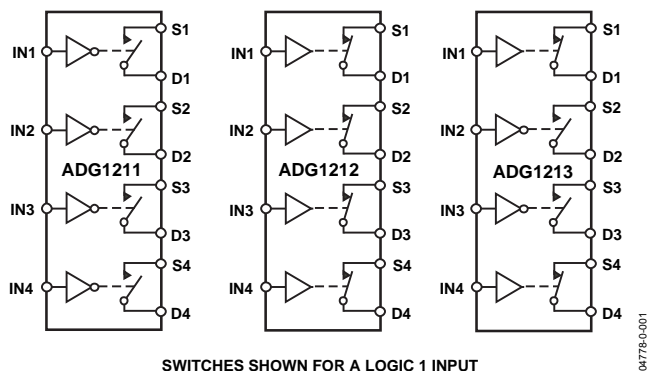
The ADG1211/ADG1212/ADG1213 are monolithic CMOS devices containing four independently selectable switches designed on an *i*CMOS process. *i*CMOS (industrial-CMOS) is a modular manufacturing process combining high voltage CMOS (complementary metal-oxide semiconductor) and bipolar technologies. It enables the development of a wide range of high performance analog ICs capable of 30 V operation in a footprint that no previous generation of high voltage parts has been able to achieve. Unlike analog ICs using conventional CMOS processes, *i*CMOS components can tolerate high supply voltages, while providing increased performance, dramatically lower power consumption, and reduced package size.

The ultralow capacitance and charge injection of these switches make them ideal solutions for data acquisition and sample-and-hold applications, where low glitch and fast settling are required. Fast switching speed coupled with high signal bandwidth make the parts suitable for video signal switching.

#### Rev. PrE

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### FUNCTIONAL BLOCK DIAGRAM



SWITCHES SHOWN FOR A LOGIC 1 INPUT

Figure 1.

*i*CMOS construction ensures ultralow power dissipation, making the parts ideally suited for portable and battery-powered instruments.

The ADG1211/ADG1212/ADG1213 contain four independent single-pole/single-throw (SPST) switches. The ADG1211 and ADG1212 differ only in that the digital control logic is inverted. The ADG1211 switches are turned on with Logic 0 on the appropriate control input, while Logic 1 is required for the ADG1212. The ADG1213 has two switches with digital control logic similar to that of the ADG1211; the logic is inverted on the other two switches. Each switch conducts equally well in both directions when on, and has an input signal range that extends to the supplies. In the off condition, signal levels up to the supplies are blocked.

The ADG1213 exhibits break-before-make switching action for use in multiplexer applications. Inherent in the design is low charge injection for minimum transients when switching the digital inputs.

### PRODUCT HIGHLIGHTS

- 2 pF off capacitance ( $\pm 15$  V supply).
- 1 pC charge injection.
- 3 V logic-compatible digital inputs:  $V_{IH} = 2.0$  V,  $V_{IL} = 0.8$  V.
- No  $V_L$  logic power supply required.
- Ultralow power dissipation:  $<0.03 \mu\text{W}$ .
- 16-lead TSSOP and 4 mm  $\times$  4 mm LFCSP packages.

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**REVISION HISTORY**

11/04—Revision PrE: Preliminary Version

# SPECIFICATIONS

## SINGLE SUPPLY

$V_{DD} = 15\text{ V} \pm 10\%$ ,  $V_{SS} = -15\text{ V}$ ,  $GND = 0\text{ V}$ , unless otherwise noted.

Table 1.

Parameter	25°C	85°C	Y Version <sup>1</sup>	Unit	Test Conditions/Comments
<b>ANALOG SWITCH</b>					
Analog Signal Range			$V_{DD}$ to $V_{SS}$	V	
On Resistance ( $R_{ON}$ )	120	160	180	$\Omega$ typ $\Omega$ max	$V_S = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$ ; Figure 20
On Resistance Match between Channels ( $\Delta R_{ON}$ )	5			$\Omega$ typ	$V_S = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$
On Resistance Flatness ( $R_{FLAT(ON)}$ )	25		50	$\Omega$ max $\Omega$ typ $\Omega$ max	$V_S = -5\text{ V}/0\text{ V}/+5\text{ V}$ ; $I_S = -10\text{ mA}$
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage, $I_S$ (Off)	$\pm 0.01$ $\pm 0.5$	$\pm 1$	$\pm 5$	nA typ nA max	$V_{DD} = +10\text{ V}$ , $V_{SS} = -10\text{ V}$ $V_S = 0\text{ V}/10\text{ V}$ , $V_D = 10\text{ V}/0\text{ V}$ ; Figure 21
Drain Off Leakage, $I_D$ (Off)	$\pm 0.01$ $\pm 0.5$	$\pm 1$	$\pm 5$	nA typ nA max	$V_S = 0\text{ V}/10\text{ V}$ , $V_D = 10\text{ V}/0\text{ V}$ ; Figure 21
Channel On Leakage, $I_D$ , $I_S$ (On)	$\pm 0.04$ $\pm 1$	$\pm 2$	$\pm 5$	nA typ nA max	$V_S = V_D = 0\text{ V}$ or $10\text{ V}$ ; Figure 22
<b>DIGITAL INPUTS</b>					
Input High Voltage, $V_{INH}$			2.0	V min	
Input Low Voltage, $V_{INL}$			0.8	V max	
Input Current, $I_{INL}$ or $I_{INH}$	0.005		$\pm 2.5$ $\pm 0.5$	$\mu\text{A}$ typ $\mu\text{A}$ max	$V_{IN} = V_{INL}$ or $V_{INH}$
Digital Input Capacitance, $C_{IN}$	5			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
$t_{ON}$	50			ns typ ns max	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ $V_S = \pm 10\text{ V}$ ; Figure 23
$t_{OFF}$	15			ns typ ns max	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ $V_S = \pm 10\text{ V}$ ; Figure 23
Break-before-Make Time Delay, $t_D$	15		1	ns typ ns min	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ $V_{S1} = V_{S2} = 10\text{ V}$ ; Figure 24
Charge Injection	1			pC typ	$V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; Figure 25
Off Isolation	75			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; Figure 26
Channel-to-Channel Crosstalk	85			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; Figure 27
Total Harmonic Distortion + Noise	0.002			% typ	$R_L = 600\ \Omega$ , $5\text{ V rms}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$
-3 dB Bandwidth	700			MHz typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; Figure 28
$C_S$ (Off)	2			pF typ	
$C_D$ (Off)	2			pF typ	
$C_D$ , $C_S$ (On)	4			pF typ	
<b>POWER REQUIREMENTS</b>					
$I_{DD}$	0.001			$\mu\text{A}$ typ $\mu\text{A}$ max	$V_{DD} = +16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$ Digital Inputs = $0\text{ V}$ or $V_{DD}$
$I_{DD}$	0.001		5.0	$\mu\text{A}$ typ $\mu\text{A}$ max	Digital Inputs = $5\text{ V}$
$I_{SS}$	0.001		5.0	$\mu\text{A}$ typ $\mu\text{A}$ max	Digital Inputs = $0\text{ V}$ or $V_{DD}$
			5.0	$\mu\text{A}$ typ $\mu\text{A}$ max	

Parameter	25°C	85°C	Y Version <sup>1</sup>	Unit	Test Conditions/Comments
I <sub>GND</sub>	0.001		5.0	μA typ μA max	Digital Inputs = 0 V or V <sub>DD</sub>
I <sub>GND</sub>	0.001		5.0	μA typ μA max	Digital Inputs = 5 V

<sup>1</sup> Temperature range for Y Version is -40°C to +125°C.

<sup>2</sup> Guaranteed by design, not subject to production test.

V<sub>DD</sub> = 12 V ± 10%, V<sub>SS</sub> = 0 V, GND = 0 V, unless otherwise noted.

**Table 2.**

Parameter	25°C	85°C	Y Version <sup>1</sup>	Unit	Test Conditions/Comments
<b>ANALOG SWITCH</b>					
Analog Signal Range			0 V to V <sub>DD</sub>	V	
On Resistance (R <sub>ON</sub> )	220	250		Ω typ Ω max	V <sub>S</sub> = +10 V, I <sub>S</sub> = -10 mA; Figure 20
On Resistance Match between Channels (ΔR <sub>ON</sub> )	1			Ω typ Ω max	V <sub>S</sub> = +10 V, I <sub>S</sub> = -10 mA
On -Resistance Flatness (R <sub>FLAT(ON)</sub> )	12			Ω typ	V <sub>S</sub> = -5 V/0 V/+5 V, I <sub>S</sub> = -10 mA
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage, I <sub>S</sub> (Off)	±0.01 ±0.5		±2.5	nA typ nA max	V <sub>DD</sub> = 12 V V <sub>S</sub> = 1 V/10 V, V <sub>D</sub> = 10 V/0 V; Figure 21
Drain Off Leakage, I <sub>D</sub> (Off)	±0.01 ±0.5		±2.5	nA typ nA max	V <sub>S</sub> = 1 V/10 V, V <sub>D</sub> = 10 V/0 V; Figure 21
Channel On Leakage, I <sub>D</sub> , I <sub>S</sub> (On)	±0.04 ±1		±5	nA typ nA max	V <sub>S</sub> = V <sub>D</sub> = 1 V or 10 V; Figure 22
<b>DIGITAL INPUTS</b>					
Input High Voltage, V <sub>INH</sub>			2.0	V min	
Input Low Voltage, V <sub>INL</sub>			0.8	V max	
Input Current, I <sub>INL</sub> or I <sub>INH</sub>	0.001		±0.5	μA typ μA max	V <sub>IN</sub> = V <sub>INL</sub> or V <sub>INH</sub>
Digital Input Capacitance, C <sub>IN</sub>	5			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
t <sub>ON</sub>	50			ns typ ns max	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>S</sub> = 8 V; Figure 23
t <sub>OFF</sub>	15			ns typ ns max	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>S</sub> = 8 V; Figure 23
Break-before-Make Time Delay, t <sub>D</sub>	15			ns typ ns min	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>S1</sub> = V <sub>S2</sub> = 8 V; Figure 24
Charge Injection	5		1	pC typ	V <sub>S</sub> = 0 V, R <sub>S</sub> = 0 Ω, C <sub>L</sub> = 1 nF; Figure 25
Off Isolation	75			dB typ	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz; Figure 267
Channel-to-Channel Crosstalk	85			dB typ	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz; Figure 27
-3 dB Bandwidth	100			MHz typ	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF; Figure 28
C <sub>S</sub> (Off)	2			pF typ	
C <sub>D</sub> (Off)	2			pF typ	
C <sub>D</sub> , C <sub>S</sub> (On)	4			pF typ	

Parameter	25°C	85°C	Y Version <sup>1</sup>	Unit	Test Conditions/Comments
POWER REQUIREMENTS					$V_{DD} = 13.2\text{ V}$
$I_{DD}$	0.001			$\mu\text{A typ}$	Digital Inputs = 0 V or $V_{DD}$
			5.0	$\mu\text{A max}$	
$I_{DD}$	0.001			$\mu\text{A typ}$	Digital Inputs = 5 V
			5.0	$\mu\text{A max}$	

<sup>1</sup> Temperature range for Y Version is  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

<sup>2</sup> Guaranteed by design, not subject to production test.

## ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

**Table 3.**

Parameter	Rating
$V_{DD}$ to $V_{SS}$	35 V
$V_{DD}$ to GND	-0.3 V to +25 V
$V_{SS}$ to GND	+0.3 V to -25 V
Analog Inputs <sup>1</sup>	$V_{SS} - 0.3$ V to $V_{DD} + 0.3$ V
Digital Inputs <sup>1</sup>	GND - 0.3 V to $V_{DD} + 0.3$ V or 30 mA, whichever occurs first
Peak Current, S or D	100 mA (pulsed at 1 ms, 10% duty cycle max)
Continuous Current, S or D	30 mA
Operating Temperature Range	
Industrial (B Version)	-40°C to +85°C
Automotive (Y Version)	-40°C to +125°C
Storage Temperature Range	-65°C to +150°C
Junction Temperature	150°C
16-Lead TSSOP, $\theta_{JA}$ Thermal Impedance	150.4°C/W
16-Lead LFCSP, $\theta_{JA}$ Thermal Impedance	30.4°C/W
Lead Temperature, Soldering	
Vapor Phase (60 s)	215°C
Infrared (15 s)	220°C

<sup>1</sup> Overvoltages at IN, S, or D are clamped by internal diodes. Current should be limited to the maximum ratings given.

### ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Only one absolute maximum rating may be applied at any one time.

**Table 4. ADG1211/ADG1212 Truth Table**

ADG1211 In	ADG1212 In	Switch Condition
0	1	On
1	0	Off

**Table 5. ADG1213 Truth Table**

Logic	Switch 1, 4	Switch 2, 3
0	Off	On
1	On	Off



### PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

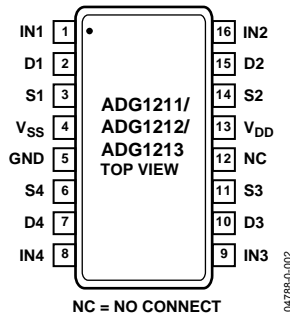


Figure 2. TSSOP Pin Configuration

ADG1211/ADG1212/ADG1213

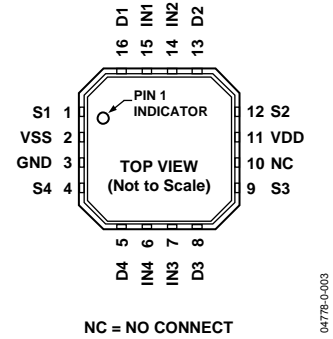


Figure 3. LFCSP Pin Configuration

Table 6. Pin Function Descriptions

Pin No.		Mnemonic	Function
TSSOP	LFCSP		
1	15	IN1	Logic Control Input.
2	16	D1	Drain Terminal. Can be an input or output.
3	1	S1	Source Terminal. Can be an input or output.
4	2	V <sub>SS</sub>	Most Negative Power Supply Potential.
5	3	GND	Ground (0 V) Reference.
6	4	S4	Source Terminal. Can be an input or output.
7	5	D4	Drain Terminal. Can be an input or output.
8	6	IN4	Logic Control Input.
9	7	IN3	Logic Control Input.
10	8	D3	Drain Terminal. Can be an input or output.
11	9	S3	Source Terminal. Can be an input or output.
12	10	NC	No Connection.
13	11	V <sub>DD</sub>	Most Positive Power Supply Potential.
14	12	S2	Source Terminal. Can be an input or output.
15	13	D2	Drain Terminal. Can be an input or output.
16	14	IN2	Logic Control Input.

## TERMINOLOGY

**I<sub>DD</sub>**

The positive supply current.

**I<sub>SS</sub>**

The negative supply current.

**V<sub>D</sub> (V<sub>S</sub>)**

The analog voltage on Terminals D and S.

**R<sub>ON</sub>**

The ohmic resistance between D and S.

**R<sub>FLAT(ON)</sub>**

Flatness is defined as the difference between the maximum and minimum value of on resistance, as measured over the specified analog signal range.

**I<sub>S</sub> (Off)**

The source leakage current with the switch off.

**I<sub>D</sub> (Off)**

The drain leakage current with the switch off.

**I<sub>D</sub>, I<sub>S</sub> (On)**

The channel leakage current with the switch on.

**V<sub>INL</sub>**

The maximum input voltage for Logic 0.

**V<sub>INH</sub>**

The minimum input voltage for Logic 1.

**I<sub>INL</sub> (I<sub>INH</sub>)**

The input current of the digital input.

**C<sub>S</sub> (Off)**

The off switch source capacitance, measured with reference to ground.

**C<sub>D</sub> (Off)**

The off switch drain capacitance, measured with reference to ground.

**C<sub>D</sub>, C<sub>S</sub> (On)**

The on switch capacitance, measured with reference to ground.

**C<sub>IN</sub>**

The digital input capacitance.

**t<sub>ON</sub>**

The delay between applying the digital control input and the output switching on. See Figure 23.

**t<sub>OFF</sub>**

The delay between applying the digital control input and the output switching off.

**Charge Injection**

A measure of the glitch impulse transferred from the digital input to the analog output during switching.

**Off Isolation**

A measure of unwanted signal coupling through an off switch.

**Crosstalk**

A measure of unwanted signal that is coupled through from one channel to another as a result of parasitic capacitance.

**Bandwidth**

The frequency at which the output is attenuated by 3 dB.

**On Response**

The frequency response of the on switch.

**Insertion Loss**

The loss due to the on resistance of the switch.



### TYPICAL PERFORMANCE CHARACTERISTICS



Figure 4. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Single Supply



Figure 7. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures, Single Supply



Figure 5. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Dual Supply



Figure 8. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures, Dual Supply



Figure 6. On Resistance as a Function of  $V_D$  ( $V_S$ ) for Different Temperatures, Single Supply



Figure 9. Leakage Currents as a Function of  $V_D$  ( $V_S$ )



Figure 10. Leakage Currents as a Function of  $V_D$  ( $V_S$ )



Figure 13. Leakage Currents as a Function of Temperature



Figure 11. Leakage Currents as a Function of  $V_D$  ( $V_S$ )



Figure 14. Supply Current vs. Input Switching Frequency



Figure 12. Leakage Currents as a Function of Temperature



Figure 15. Charge Injection vs. Source Voltage



Figure 16.  $T_{ON}/T_{OFF}$  Times vs. Temperature



Figure 18. Crosstalk vs. Frequency



Figure 17. Off Isolation vs. Frequency



Figure 19. On Response vs. Frequency

TEST CIRCUITS

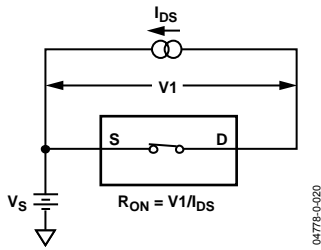


Figure 20. Test Circuit 1—On Resistance

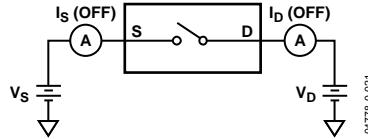


Figure 21. Test Circuit 2—Off Leakage

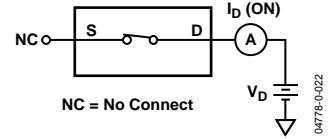


Figure 22. Test Circuit 3—On Leakage

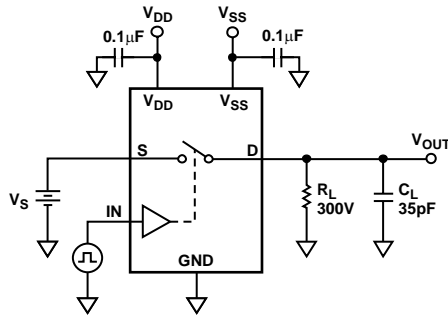


Figure 23. Test Circuit 4—Switching Times

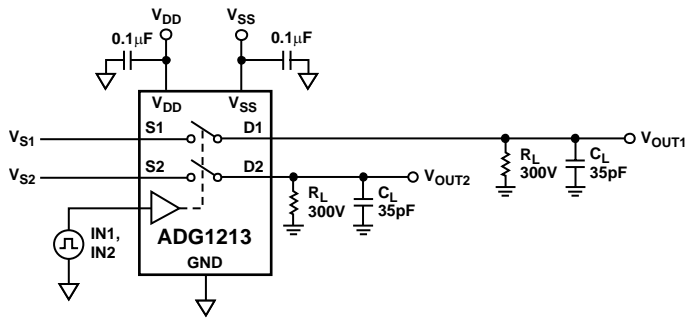
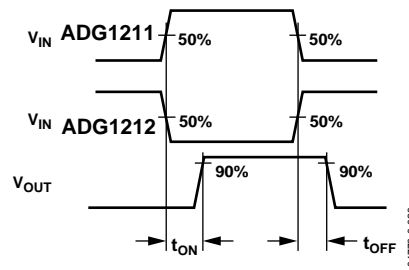


Figure 24. Test Circuit 5—Break Before Make Time Delay

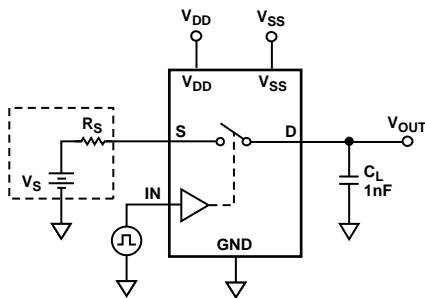
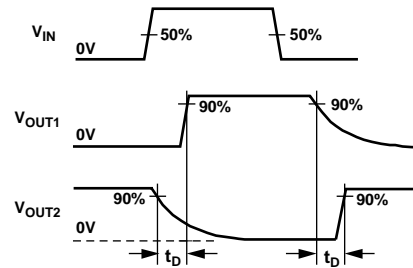
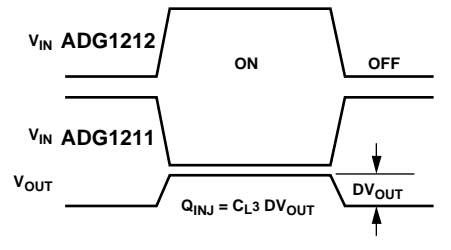


Figure 25. Test Circuit 6—Charge Injection



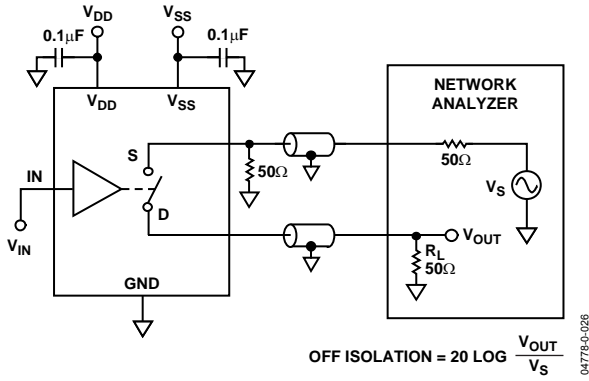


Figure 26. Test Circuit 7—Off Isolation

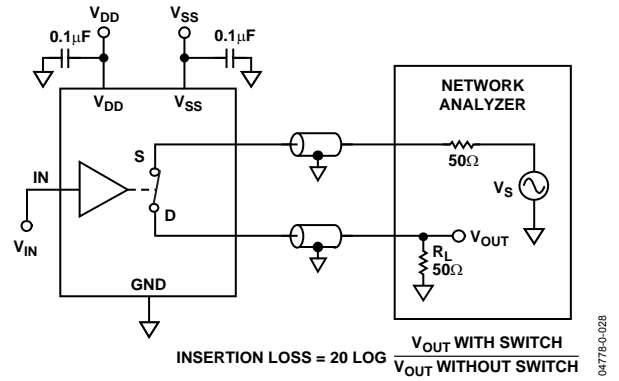


Figure 28. Test Circuit 9—Bandwidth

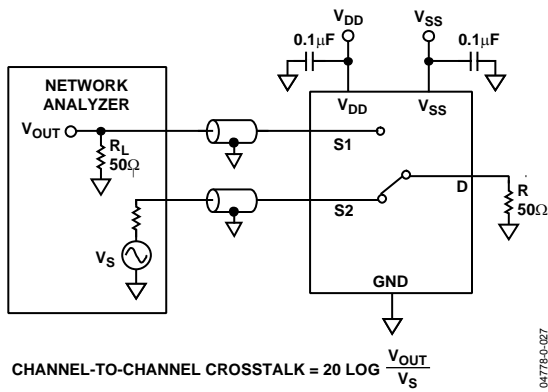


Figure 27. Test Circuit 8—Channel-to-Channel Crosstalk

OUTLINE DIMENSIONS

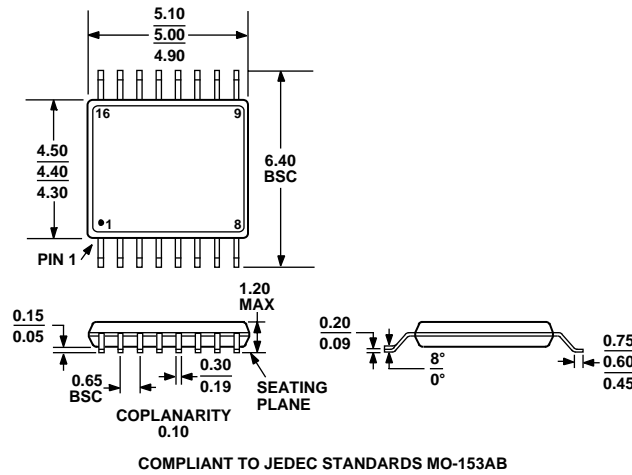


Figure 29. 16-Lead Thin Shrink Small Outline Package [TSSOP] (RU-16)  
Dimensions shown in millimeters

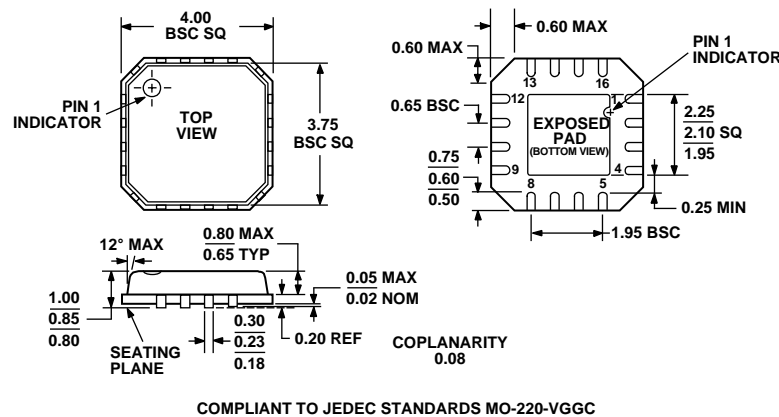


Figure 30. 16-Lead Lead Frame Chip Scale Package [VQ\_LFCSP] 4 mm × 4 mm Body, Very Thin Quad (CP-16-4)  
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADG1211YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG1211YCP	-40°C to +125°C	Lead Frame Chip Scale Package (LFCSP)	CP-16-4
ADG1212YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG1212YCP	-40°C to +125°C	Lead Frame Chip Scale Package (LFCSP)	CP-16-4
ADG1213YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG1213YCP	-40°C to +125°C	Lead Frame Chip Scale Package (LFCSP)	CP-16-4

**NOTES**

**NOTES**